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# The Need for a Life Cycle Assessment of Drone-Based Commercial Package Delivery

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## **The Need for a Life Cycle Assessment of Drone-Based Commercial Package Delivery**

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Unmanned Aerial Vehicles (UAV's) or "drones" are now widely used in military surveillance and tactical applications, with recent pilot programs in cargo transport [1]. Use of the technology is expanding to civilian government and research applications, and small, battery-powered UAV's are available to hobbyists.

Plans for commercial UAV's for freight have recently been announced by a number of companies, including Deutch Post (DHL) [2], Zookal, Inc. (an Australian textbook service) [3], and Amazon, Inc., which has stated plans for a UAV-based home package delivery program within 5 years [4].

Commercial freight drones are currently illegal in the U.S. Consequently, commercial interests such as Amazon, Inc. will be lobbying for new regulatory allowances in the coming years. The Federal Aviation Administration and other government entities must balance safety and other public interests against the potential commercial benefits of UAV freight. Controversy over commercial UAV's has so far centered on the privacy implications of the devices, which are significant. However, no assessment has yet been made of the energy and environmental implications of widespread UAV-based delivery. Such an accounting of environmental impacts would inform current regulatory discussions about whether and how much commercial drone traffic should be permitted.

The widespread use of UAV's poses two obvious questions with respect to impacts on the environment and energy system: (1) Do they lead to significantly higher energy use and emissions compared with current methods? (2) Does their demand for batteries significantly stress the supply of scarce materials and displace other beneficial uses of batteries, e.g. by slowing the penetration of electric vehicles or grid-attached energy storage?

Previous studies have shown that transport of goods by conventional aircraft is about 4 times more carbon-intensive than transport by truck, which is in turn about 10 times more carbon-intensive than transport by rail. A delivery system based on UAV's carrying single packages promises a new class of delivery speed -- Amazon has claimed 30 minutes from time of purchase. If it follows the trend set by other modes, this jump in speed could come at the cost of another order-of-magnitude increase in energy intensity and carbon emissions. On the other hand, perhaps the logistical benefits of integrating UAV delivery for the last leg of a package's journey with other modes would lead to a net energy savings. In the current system, the truck carrying packages for the last leg of delivery carries most of those packages many more miles than they would travel on individual direct routes. Even if UAV delivery uses a comparable amount of energy relative to truck delivery, it is worthwhile to estimate whether the additional electricity demand is significant in the context of already-stressed electricity grids.

In prototypes and media depictions so far, UAV's for package delivery have appeared as four- or eight-rotor, battery powered units capable of carrying about 10 lbs. Based on specifications of commercially-available models, meaningful flight ranges for these types of vehicles appears to require both large battery packs that are recharged many times per day

and advances in energy storage density of batteries. Electric vehicles also require large quantities of advanced batteries and the viability and rate of adoption of electric vehicles may be sensitive to the price of batteries [6]. Consequently, it is useful to estimate the demand for batteries and related hardware by widespread use of UAV's compared to that expected for cars and other applications, and consider whether the supply of scarce materials would be stressed.

Although UAV's for commercial package delivery have so far been battery-powered in public depictions, we should consider the possibility that operators would turn to fossil-fueled models because of the inherent advantages in energy density and hence range. If emissions from other types of small combustion engines (lawn mowers, leaf blowers) are a guide, such a move could be disastrous for local air quality. A thoughtful analysis of the issue now may encourage regulators to preclude such models in upcoming rules.

The answers to none of the above questions are currently obvious, but we can address them with relatively straightforward calculations and established techniques in Life Cycle Assessment. We would have to develop a basic physical model of drone energy use and make several assumptions about the penetration of UAV delivery: number of packages and their average weight and distance to be traveled. The results of such a study would give us a good handle on the potential energy and environmental impacts of widespread UAV delivery.

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